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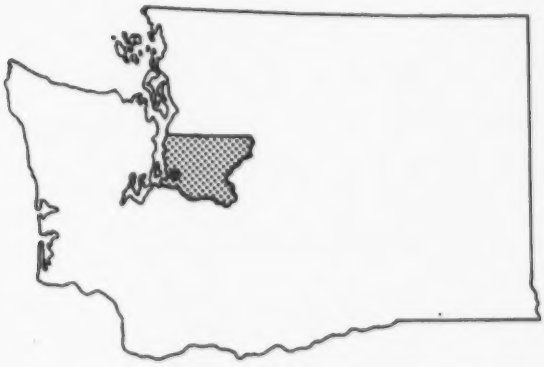
FLOOD INSURANCE STUDY

CITY OF KENT, WASHINGTON
KING COUNTY



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OCTOBER 1, 1980

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TABLE OF CONTENTS

		Page
1.0	INTRODUCTION	1
1.1	Purpose of Study	1
1.2	Coordination	1
1.3	Authority and Acknowledgments	1
2.0	AREA STUDIED	2
2.1	Scope of Study	2
2.2	Community Description	2
2.3	Principal Flood Problems	6
2.4	Flood Protection Measures	7
3.0	ENGINEERING METHODS	8
3.1	Hydrologic Analyses	9
3.2	Hydraulic Analyses	9
4.0	FLOOD PLAIN MANAGEMENT APPLICATIONS	12
4.1	Flood Boundaries	12
4.2	Floodways	13
5.0	INSURANCE APPLICATION	20
5.1	Reach Determinations	20
5.2	Flood Hazard Factors	21
5.3	Flood Insurance Zones	21
5.4	Flood Insurance Rate Map Description	23
6.0	OTHER STUDIES	23
7.0	LOCATION OF DATA	24
8.0	BIBLIOGRAPHY AND REFERENCES	24

TABLE OF CONTENTS (Cont'd)

Page

FIGURES

Figure 1 - Vicinity Map..... 3
Figure 2 - Floodway Schematic..... 20

TABLES

Table 1 - Summary of Discharges..... 10
Table 2 - Floodway Data..... 14
Table 3 - Flood Insurance Zone Data..... 22

EXHIBITS

Exhibit 1 - Flood Profiles

Green River	Panels 01P-05P
Mill Creek	Panels 06P-08P
Springbrook Creek	Panels 09P-10P

Exhibit 2 - Flood Boundary and Floodway Map

PUBLISHED SEPARATELY:

Flood Insurance Rate Map Index
Flood Insurance Rate Map

FLOOD INSURANCE STUDY

1.0 INTRODUCTION

1.1 Purpose of Study

The purpose of this Flood Insurance Study is to investigate the existence and severity of flood hazards in the City of Kent, King County, Washington, and to aid in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. Initial use of this information will be to convert Kent to the regular program of flood insurance by the Federal Insurance Administration. Further use of the information will be made by local and regional planners in their efforts to promote sound land use and flood plain development.

1.2 Coordination

Streams to be studied by detailed methods were identified at a meeting attended by representatives of the City of Kent and the Federal Insurance Administration on April 8, 1976.

During the course of the work, the study contractor maintained contact with the U.S. Army Corps of Engineers; the King County Division of Hydraulics; and the City of Kent, Department of Public Works.

On May 29, 1979, the results of the study were reviewed at an intermediate coordination meeting attended by representatives of the City of Kent, the study contractor, and the Federal Insurance Administration.

The results of this study were reviewed at a final community coordination meeting held on April 28, 1980. Attending the meeting were representatives of the Federal Insurance Administration, the study contractor, and the city. No problems were raised at the meeting.

1.3 Authority and Acknowledgments

The source of authority for this Flood Insurance Study is the National Flood Insurance Act of 1968, as amended.

The hydrologic and hydraulic analyses for this study were performed by Tudor Engineering Company, for the Federal Insurance Administration, under Contract No. H-4025, Amendment 13. This work, which was completed in June 1979, covered all significant flooding sources affecting the City of Kent.

2.0 AREA STUDIED

2.1 Scope of Study

This Flood Insurance Study covers the incorporated areas of the City of Kent, King County, Washington. The area of study is shown on the Vicinity Map (Figure 1).

A small area of unincorporated land is enclosed within Kent, near Interstate Highway 5, and is excluded from this study.

The following areas were studied by detailed methods: Green River and Springbrook Creek, for their entire length within the corporate limits; Mill Creek, from its confluence with Springbrook Creek to approximately 5.5 miles upstream; and numerous shallow-flooding areas throughout Kent.

Those areas studied by detailed methods were chosen with consideration given to all proposed construction and forecasted development through 1984.

2.2 Community Description

Kent is located in the southwestern corner of King County in western Washington, within 2 to 5 miles of the waters of Puget Sound. It lies along and to the east of Interstate Highway 5, approximately 18 miles south of Seattle and 18 miles northeast of Tacoma. State Highways 181 and 167 run north to south through the city, as do the Burlington Northern and Chicago, Milwaukee, St. Paul & Pacific Railroads. Kent forms part of a continuous urbanized area stretching south of Duwamish and Green Rivers.

Settlement and agricultural development in the Green River valley began in the 1850s. According to the 1890 census, Kent was incorporated with a population of 853. It grew to 1908 by 1910 and 3278 by 1950. Poplation growth accelerated and reached 9,017 by 1960 and 16,928 by 1975 (References 1 and 2). Since 1950, the growth has been associated with an expansion of the incorporated area. Prior to 1940, the city covered an area of 1.5 square miles. It had expanded to 13.7 square miles by 1960 (Reference 1) and, by 1975, approximately 16.6 square miles. The incorporated area of the city extends for a distance of 6 miles in a roughly north-south direction. Green River flows generally northwesterly, with meanders through the southern and western portions of the city. West of the river, there is a narrow flood plain bounded by a steep valley wall rising 400 feet in approximately 0.25 mile.

Most of Kent lies on the 2-mile-wide flood plain east of Green River. Ground elevations in this area range from 20 to 40 feet. On either side of the valley, the terrain ascends gradually to elevations of 400 to 500 feet. The eastern side of the valley is drained by several creeks. The principal creeks in the Kent area are Mill Creek, Springbrook Creek, and Garrison Creek.

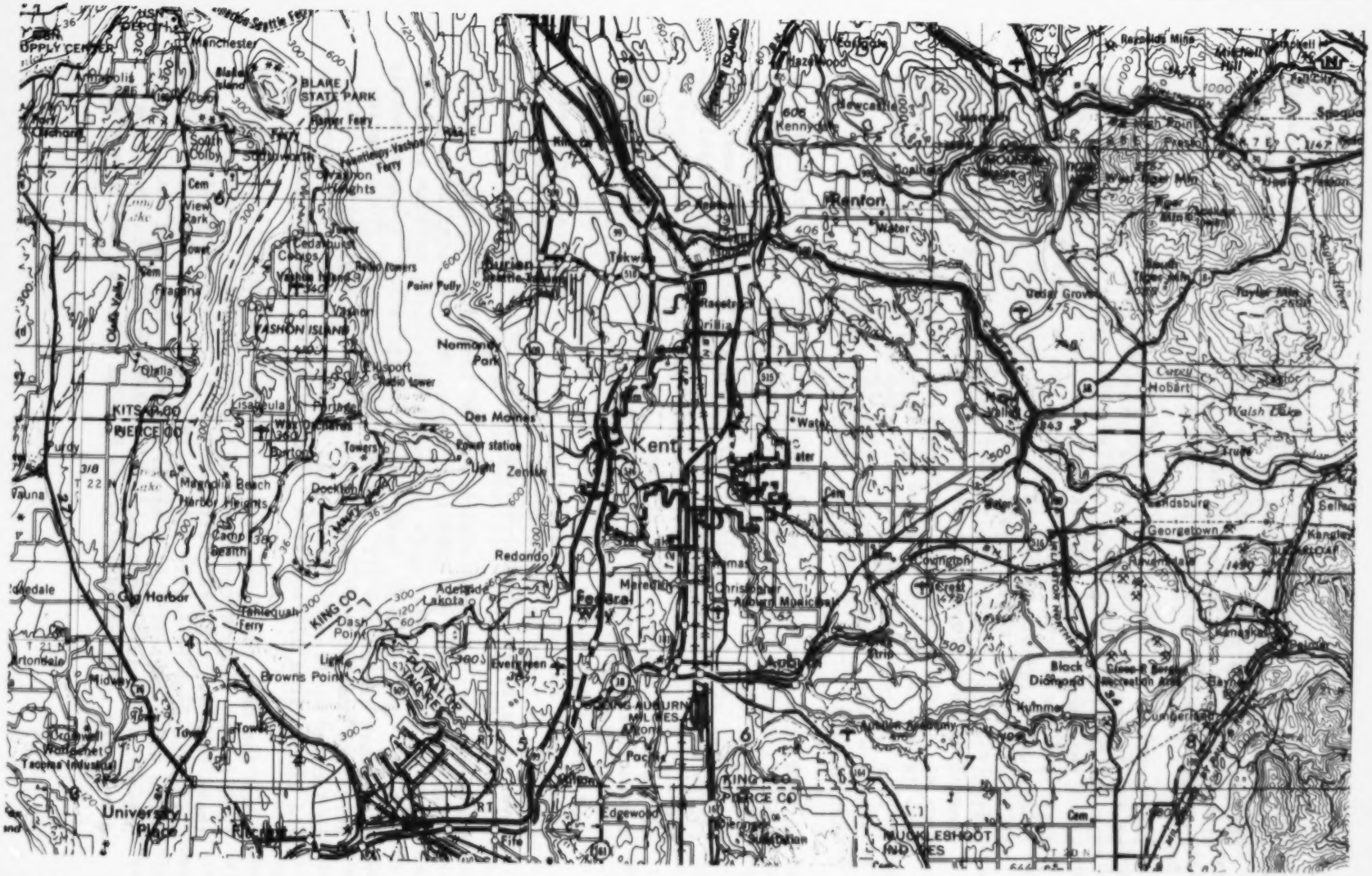

FIGURE 1

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF KENT, WA
(KING CO.)

APPROXIMATE SCALE

4 0 4 8 12 MILES

VICINITY MAP

Another stream, known as Mill Creek, drains an area west of Auburn and joins Green River in southern Kent. Manmade changes have affected the course of the east-side streams. These changes began around the turn of the century to facilitate agricultural drainage and have affected an estimated 13.75 miles (Reference 3).

The commercial center of the city is located in the south end of the incorporated area, near the intersection of State Highway 516 and Central Avenue. Residential development has spread primarily along the ascending ground east of the flood plain, and includes extensive areas outside the corporate limits. The flood plain itself was originally farmland, a use which predominated until the early 1960s. Urban development has sufficiently displaced agriculture to make the Green River valley one of the fastest growing urban employment centers in the Puget Sound region (Reference 4). Agricultural and noncommercial pastureland account for only 18 percent of the land use in the east Green River watershed. In King County, approximately 2640 acres of prime agricultural land have been industrialized in the past 10 years (Reference 3), much of it is Green River valley land around Kent.

In 1962, damaging floodflows in Green River were controlled by Howard A. Hanson Dam. As a result, Green River valley became an attractive area for industrial development. Industrial and commercial activity occupies the flood plain between the west valley wall and State Highway 167. By 1973, 3000 acres within the city had been zoned for industrial use, of which 75 percent was vacant (Reference 5). At that time, Kent boasted over 100 manufacturing concerns, including Boeing Aerospace (6300 employees), Western Electric (450 employees), Heath Tecna Corporation (440 employees), and Tally Corporation (425 employees). The range of products and activities included wholesale grocers, long-haul trucking, automobile distribution, computer equipment, aluminum beverage cans, and communications and aerospace equipment (Reference 5).

The headwaters of Green River, east of Lester, Washington (southeast of Kent), are near the 5000-foot elevation. Tributaries in the upper 30 miles of the basin descend as turbulent streams in steep valleys. In this area, mean annual precipitation is approximately 100 inches (Reference 6). Howard A. Hanson Dam, a flood control structure completed by the U.S. Army Corps of Engineers in 1962, is located upstream of Kent, east of Black Diamond, and impounds the runoff from 220 square miles of Green River catchment.

Below the dam, the river flows in Green River Gorge for 4 miles, then in the upper Green River valley for 15 miles. Throughout these reaches, tributary streams join the river, augmenting the catchment area to nearly 400 square miles. From the upper valley, Green River emerges into a broad alluvial valley and onto an outwash plain just above Auburn. At Auburn, flow changes from a westerly to a northerly course through a valley having average

widths between 2 and 3 miles. Green River flows another 24 miles to its mouth, in Elliott Bay at Seattle. The 11-mile reach above the mouth is known as Duwamish River, of which the lower 5 miles are maintained as a navigable waterway (Reference 6). Most of Kent is drained by Mill Creek and Springbrook Creek. Both streams originate on the steep valley walls in southeast Kent and flow northerly to Orilla, near the northern corporate limits. There Mill Creek empties into Springbrook Creek. From that location, Springbrook Creek flows northerly for approximately 2 miles to its confluence with Black River. Springbrook Creek drains approximately 22 square miles, including the Mill Creek drainage area, much of which can be classified as urban. The higher portions along the eastern valley walls are primarily residential, while the lower areas adjacent to Green River are generally zoned for commercial, industrial, and residential development.

The climate of the region is predominantly a midlatitude, west coast, marine type, with most of the airmasses originating over the Pacific Ocean. In late fall and winter, these masses are moist and approximately the same temperature as the ocean surface. Orographic lifting and cooling, as airmasses move inland, result in cloudiness and widespread precipitation throughout King County. Kent receives 34 inches of rainfall annually of which 50 percent occurs from October through January, and 75 percent occurs from October through March (Reference 7). Average annual snowfall is 8.6 inches (Reference 5). During the warmest summer months, afternoon temperatures are around 75°F. Tempertures reach 90°F on the average of 2 days per year. In winter, afternoon temperatures range from 40°F to 50°F. The Japan Current generally moderates the winter temperatures, but below-freezing temperatures occur on an average of 16 nights every winter (Reference 8).

Geologic activity has had a major influence on the terrain of the Puget Sound region. The area was repeatedly occupied by the Puget lobe of the Cordilleran glacier advancing from British Columbia. The last glaciation (Vashon) took place approximately 13,500 year ago. It is estimated this glacier was approximately 3000 feet thick at Renton. During this period, most west-trending valleys were filled with glacial drift consisting of rocks, gravel, and sand, while preexisting, north-trending valleys like Green River were scoured deeper. As the ice retreated farther north, the Strait of Juan de Fuca became ice free and the ocean once more covered Green River valley. This embayment slowly filled with alluvium carried by White, Green, and Cedar Rivers creating a flood plain filled with a series of bogs and swamps. These alluvial deposits vary from a few feet deep near the hillsides to 400 to 500 feet thick in the central lowland area. This alluvium forms some of the most fertile soil in the Pacific Northwest. Glacial till and outwash deposits from the Vashon glaciation are the chief components of the uplands. These deposits vary from 25 to 200 feet in depth above bedrock.

The higher portions along the eastern valley walls are generally wooded with thick underbrush. They are zoned primarily for residential use. The lower, flat areas adjacent to Green River are generally zoned for commercial, industrial, and residential development. Undeveloped areas throughout this region are used for agriculture, and open spaces have been cleared of trees and other tall vegetation.

2.3 Principal Flood Problems

Flood-caused damage to crops and property in lower Green River valley has been a problem since the earliest settlements. Flooding occurred almost annually, but the impact was minimal to farmland when pasture and hayfields were the dominant land use.

Most floods occur during the winter as a result of heavy rainfall. After urbanization, the impact of flooding became more severe. Rapid increase in construction of roads, housing, and parking lots accelerated the amount of runoff reaching the valley floor. Industrial landfills in the valley are frequently located with no regard to natural drainage patterns.

During periods of excessive precipitation, surface and subsurface runoff from the steep valley walls cause ground-water elevations in the valley floor to rise significantly. This creates open ponding in topographically depressed areas throughout Kent. This condition is further aggravated by floodflow, and corresponding high-water elevations on Green River which prevent natural drainage of subsurface water. In other areas, the overlying soils are generally less pervious than the deeper sands, and runoff collects in ponds perched above the water table.

Flooding from Mill Creek and its numerous tributary ditches is caused, in part, by overburdened channel capacities, but to a much larger extent by backwater collecting uptream of undersized culverts. A typical example is the flooding on Mill Creek between Titus and Smith Streets (in the area of cross sections AM and AN) and on the upstream side of State Highway 167 (near cross section AC). Flooding from Green River occurs mainly on the west side of the river where tops of levees are below expected flood stages.

A typical storm that can occur in Green River basin once every 2.5 years (40-percent frequency) was that of November 1962. Rainfall began after 1 a.m. on the 24th of November and 1.18 inches were recorded during the day. On the 25th of November, 1.46 inches fell. This rainfall caused creeks to overflow and ponding to occur over large areas of the valley. On November 26, an additional 0.52 inch of rain fell, and flooding covered an area of 7000 acres. High flows in lower Green River valley persisted for 10 days and prevented drainage of the flooded lands until river levels subsided (Reference 3).

The maximum flood on Green River since the construction of Howard A. Hanson Dam occurred in January 1965. It flooded 7500 acres. Ponding lasted 2 weeks or longer in many areas. Storms of this magnitude are expected to occur once every 5 years. The most recent such flood occurred in December 1975. No frequency information is available on this flood.

The land in lower Green River valley from Auburn to Renton was inundated by large floods, such as occurred on December 12, 1955, and February 11, 1951, until the construction of Howard A. Hanson Dam. Since 1962, Howard A. Hanson Dam has prevented that magnitude of flooding. During the floods of January 1965 and December 1975, discharges downstream of the dam were effectively reduced to nondamaging levels. The effect of the dam is to prevent destructive over-the-bank flooding from Green River. This high water prevents discharge of runoff waters carried by the various tributaries. High water on Green River below Auburn required pumping of these tributary flows into Green River. The peak flows that are authorized for flood control operation below the dam create hazards when levees on Green River are low, particularly north of Kent. Additional pumping from tributaries into Green River during high water will not be practicable until levees on Green and Duwamish Rivers are improved to a uniform standard. Urban flood damages include the cost of cleaning, repairing, or replacing items within buildings that have been damaged by floodwaters, and removing silt and debris from lawns and other landscaped areas, and/or replacing those which have been ruined.

Problems resulting from past floods include damage to the public street and highway systems, disruption of power and communication systems, and damage to septic tanks and domestic water-supply systems. When these systems have been rendered inoperable and unsafe, a general health hazard is created.

2.4 Flood Protection Measures

The U.S. Army Corps of Engineers operates Howard A. Hanson Dam at Eagle Gorge on upper Green River. Completed in 1962, the dam provides approximately a 500-year level of protection against overbank flooding by Green River.

The dam is a rockfill embankment approximately 235 feet high with a gated spillway and a maximum reservoir elevation of 1222 feet. Stored water is released as soon as possible after a flood in anticipation of a second flood. The U.S. Army Corps of Engineers operation of Howard A. Hanson Dam provides that all runoff be passed through the dam until the flow at the Auburn gage (No. 12113000) is expected to reach 12,000 cubic feet per second (cfs). At that point, further releases are regulated to maintain no more than 12,000 cfs at Auburn.

Channelization and diking protects the flood plain. Along Green River, a total of 12 miles of levees have been constructed, primarily downstream from Kent. The King County Division of Hydraulics is responsible for maintenance of the levees. Since the adoption of enabling legislation by the State of Washington in 1945, the State and King County have combined to control riverbank erosion.

Floodflows on Springbrook Creek are discharged into Black River, just upstream of the P-1 pumping station location approximately 1 mile downstream of Interstate Highway 405. This pumping station, constructed in 1972, is operated and maintained by King County. The facility has a dual purpose: to prevent Green River floodwaters from entering and inundating the low-lying east valley lands; and to pump water from relatively low elevations on Black River into Green River at higher elevations. The pumping station is part of an unpublished Watershed Work Plan, designed in 1965 by the U.S. Soil Conservation Service in cooperation with King County. It includes a system of integrated drainage channels known as P-channels, but it is not expected that they will be built.

Under Chapter 86.16 of the Revised Code of Washington, Green River is in Flood Control Zone No. 2. Pursuant to the statute, flood plain management in these zones is administered by county and city authorities. Specific provisions for flood plain management, designed to reduce flood damage to urban developments, have been formulated jointly by King County, the City of Kent, and the other municipalities located in Green River valley. These provisions require all new urban developments in flood-prone areas to floodproof against 100-year flood conditions. To meet these floodproofing requirements, developers must raise the ground surface to an elevation that is 1 foot above the predicted water surface caused by the 100-year flood.

Flood forecasting and protection is facilitated by an agreement between the U.S. Army Corps of Engineers, Seattle District, and King County, whereby, the King County Division of Hydraulics will be advised when a flow of 10,000 cfs in Green River is expected to reach Auburn. The King County Division of Hydraulics has agreed to monitor river conditions and to be responsible for encroachment on the safe carrying capacity of the levees.

3.0 ENGINEERING METHODS

For the flooding sources studied in detail in the community, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this study. Flood events of a magnitude which are expected to be equalled or exceeded once on the average during any 10-, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for flood plain management and for flood insurance premium rates. These events, commonly termed

the 10-, 50-, 100-, and 500-year floods, have a 10, 2, 1, and 0.2 percent chance, respectively, of being equalled or exceeded during any year. Although the recurrence interval represents the long term average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than 1 year are considered. For example, the risk of having a flood which equals or exceeds the 100-year flood (1 percent chance of annual occurrence) in any 50-year period is approximately 40 percent (4 in 10), and, for any 90-year period, the risk increases to approximately 60 percent (6 in 10). The analyses reported here reflect flooding potentials based on conditions existing in the community at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

3.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish the peak discharge-frequency relationships for floods of the selected recurrence intervals for each stream studied in detail in the community.

On Green River, releases are controlled by Howard A. Hanson Dam so as not to exceed a discharge of 12,000 cfs at Auburn for all floods up to the 500-year event (Reference 6).

No streamflow records are available for Mill Creek or Springbrook Creek. Hydrologic analyses for these drainage basins were performed, but not published, by the U.S. Soil Conservation Service, using synthetic hydrography methodology (Reference 9) and the TR-20 computer program (Reference 10). Results of this study were made available and incorporated into a computerized runoff-routing model developed by the study contractor to utilize the U.S. Soil Conservation Service synthetic hydrograph criteria. Hydrographs representing the 10-and 100-year return storm runoffs were generated and routed throughout the study reach. Precipitation depth for the expected 24-hour, 10-year, and 100-year return storms were obtained using the National Oceanic and Atmospheric Administration Precipitation-Frequency Atlas (Reference 11) and checked against precipitation gage records at Seattle-Tacoma Airport. Intensity distribution was also based on the Seattle-Tacoma Airport rainfall records. The expected 8-day, 100-year return storm precipitation depth was used to determine the extent of surface ponding in low-lying areas.

Peak discharge-drainage area relationships for Green River, Mill Creek, and Springbrook Creek are shown in Table 1.

3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of streams in the community were carried out to provide estimates of the elevations of floods of the selected recurrence intervals along each stream studied in the community.

Table 1. Summary of Discharges

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (Cubic Feet per Second) 10-Year	50-Year	100-Year	500-Year
Green River					
At Kent	400	12,000[1]	12,000[1]	12,000[1]	12,000[1]
Mill Creek					
At Upstream Study Limit	2.8	270	N/A	435	N/A
Downstream of State Highway 167	3.1	90	N/A	95	N/A
At Confluence With Springbrook Creek	9.2	380	N/A	650	N/A
Springbrook Creek					
At Upstream Study Limit	0.5	60	N/A	100	N/A
Downstream of Confluence With Mill Creek (River Mile 3.03)	16.1	680	N/A	1,055	N/A
At Confluence With Black River	21.9	585	N/A	1,105	N/A

[1]Discharges Constant Due to Controlled Release From Howard A. Hanson Dam

The U.S. Army Corps of Engineers had previously developed the physical data and determined flow coefficients that were used to develop the step-backwater computer model for Green River (Reference 6).

Results of the Green River study (Reference 6) show that the 10-, 50-, 100-, and 500-year water-surface elevations, through Kent, are represented by a single water-surface profile due to controlled discharge releases at Howard A. Hanson Dam. This profile was taken from the Flood Insurance Study for King County (Reference 6).

By agreement between the study contractor and the Federal Insurance Administration, the 50- and 500-year profiles for Springbrook Creek and Mill Creek were not computed due to minimal differences between the 10-, 50-, 100-, and 500-year flood elevations.

Water-surface elevations for floods of the 10- and 100-year recurrence intervals for Mill Creek and Springbrook Creek were computed through use of the U.S. Army Corps of Engineers HEC-2 step-backwater program (Reference 12). Flooding along these creeks is due in part to overburdened channel sections and, in part, to backwater ponding upstream of roadway culverts. Ponding water-surface elevations were established using an inhouse reservoir routing computer program incorporating the Modified Puls routing techniques.

Cross section data for Mill Creek and Springbrook Creek were obtained from field surveys by the study contractor.

Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles (Exhibit 1). For stream segments for which a floodway is computed (Section 4.2), selected cross section locations are also shown on the Flood Boundary and Floodway Map (Exhibit 2).

Roughness values (Manning's "n") were obtained by field inspection. Channel roughness values ranged from 0.035 to 0.055, and overbank values ranged from 0.080 to 0.150.

The starting water-surface elevation on Springbrook Creek was based on expected pumping criteria and floodwater storage capacity at the Black River pumping station. The inflow hydrograph was routed through the pumps at a constant outflow of 300 cfs. The hydrograph excess was stored and ponding elevations were obtained from a storage-elevation curve.

The starting water-surface elevation on Mill Creek was obtained from the Springbrook Creek flood profile.

Flood profiles were drawn showing computed water-surface elevations to an accuracy of 0.5 foot for floods of the selected recurrence intervals (Exhibit 1).

There are numerous shallow-flooding areas within Kent. Excessive precipitation in combination with high ground-water elevations cause open ponding in low-lying areas. Water-surface elevations of these ponding areas not drained by Mill or Springbrook Creeks were obtained by comparing individual elevation-storage curves with total runoff volumes determined from 8-day hydrographs as described in Section 3.1.

Shallow-flooding elevations in the area of Mill Creek, to the east of cross sections AI and AJ, were derived using the HEC-2 step-backwater program (Reference 12) together with field surveys and information from topographic maps (Reference 13).

All elevations are referenced to the National Geodetic Vertical Datum of 1929 (NGVD). Elevation reference marks used in the study are shown on the maps.

4.0 FLOOD PLAIN MANAGEMENT APPLICATIONS

A prime purpose of the National Flood Insurance Program is to encourage State and local governments to adopt sound flood plain management programs. Each Flood Insurance Study, therefore, includes a flood boundary map designed to assist communities in developing sound flood plain management measures.

4.1 Flood Boundaries

In order to provide a national standard without regional discrimination, the 100-year flood has been adopted by the Federal Insurance Administration as the base flood for purposes of flood plain management measures. The 500-year flood is employed to indicate additional areas of flood risk in the community. For each stream studied in detail, the boundaries of the 100- and 500-year floods have been delineated using the flood elevations determined at each cross section; between cross sections, the boundaries were interpolated using topographic maps at a scale of 1:2400, with a contour interval of 5 feet (Reference 13).

The study contractor has determined that some areas shown on the Federal Insurance Administration's Flood Hazard Boundary Map (Reference 14) are areas of minimal flooding; therefore, they were not delineated on the maps.

Flood boundaries for the 100- and 500-year floods are shown on the Flood Boundary and Floodway Map (Exhibit 2). Small areas within the flood boundaries may lie above the flood elevations and, therefore, not be subject to flooding; owing to limitations of the map scale, such areas are not shown.

4.2 Floodways

Encroachment on flood plains, such as artificial fill, reduces the flood-carrying capacity and increases flood heights, thus increasing flood hazards in areas beyond the encroachment itself. One aspect of flood plain management involves balancing the economic gain from flood plain development against the resulting increase in flood hazard. For purposes of the National Flood Insurance Program, the concept of a floodway is used as a tool to assist local communities in this aspect of flood plain management. Under this concept, the area of the 100-year flood is divided into a floodway and a floodway fringe. The floodway is the channel of a stream, plus any adjacent flood plain areas, that must be kept free of encroachment in order that the 100-year flood be carried without substantial increases in flood heights. As minimum standards, the Federal Insurance Administration limits such increases in flood heights to 1.0 foot, provided that hazardous velocities are not produced.

The floodways developed in this study were based on equal-conveyance reduction from each side of the flood plain. However, for Mill Creek and Springbrook Creek, there were areas of backwater ponding upstream of roadway culverts where floodway requirements were computed based on storage routing criteria. After the 100-year ponding water-surface elevations were established, using reservoir routing by Modified Puls routing techniques, the floodway encroachment limits were determined by reducing the width of the flood plain to obtain the required surcharge for each ponding area upstream of the culvert. The flow with the increased elevation was then routed through the culvert using Modified Puls routing techniques. Because this method involves the instantaneous discharge and storage, velocity, cross sectional area, and widths are now shown in the Floodway Data Table for those cross sections which are located within this storage floodway. Cross sections AC and AD on Mill Creek are located within a storage floodway area.

The results of these computations are tabulated at selected cross sections for each stream segment for which a floodway is computed (Table 2).

As shown on the Flood Boundary and Floodway Map (Exhibit 2), the floodway boundaries were determined at cross sections; between cross sections, the boundaries were interpolated. In cases where the floodway and 100-year flood boundaries are close together, only the floodway boundary has been shown.

The area between the floodway and the boundary of the 100-year flood is termed the floodway fringe. The floodway fringe thus encompasses the portion of the flood plain that could be completely obstructed without increasing the water-surface elevation of the 100-year flood more than 1.0 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to flood plain development are shown in Figure 2.

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD)			
Green River								
U	1,200	150/70[2]	3,202	3.7	29.9	29.9	29.9	0.0
V	3,680	150/130[2]	2,836	4.2	30.8	30.8	30.8	0.0
W	6,000	200/150[2]	3,893	3.1	31.5	31.5	31.5	0.0
X	8,040	230/30[2]	2,960	4.1	32.0	32.0	32.0	0.0
Y	10,390	180	3,051	3.9	32.7	32.7	32.7	0.0
Z	12,570	200	2,948	4.1	33.3	33.3	33.3	0.0
AA	14,990	200	3,254	3.7	33.9	33.9	33.9	0.0
AB	17,590	200	3,155	3.8	34.4	34.4	34.4	0.0
AC	19,130	190	2,746	4.4	34.9	34.9	34.9	0.0
AD	20,700	170	3,013	4.0	35.3	35.3	35.3	0.0
AE	23,200	190	3,530	3.4	36.0	36.0	36.0	0.0
AF	25,680	260	2,709	4.4	36.7	36.7	36.7	0.0
AG	27,780	200	3,090	3.9	37.3	37.3	37.3	0.0
AH	29,700	140	3,186	3.8	37.8	37.8	37.8	0.0
AI	30,610	180	3,123	3.8	37.9	37.9	37.9	0.0
AJ	31,820	180	3,097	3.9	38.2	38.2	38.2	0.0
AK	33,450	240/30[2]	2,638	4.5	38.8	38.8	38.8	0.0
AL	35,730	160/20[2]	2,882	4.2	39.4	39.4	39.4	0.0
AM	36,880	150/20[2]	3,040	3.9	39.9	39.9	39.9	0.0
AN	38,910	190/50[2]	3,236	3.7	40.2	40.2	40.2	0.0
AO	40,570	180	3,265	3.7	40.7	40.7	40.7	0.0
AP	42,070	190	3,050	3.9	41.5	41.5	41.5	0.0
AQ	43,910	200	3,025	4.0	42.1	42.1	42.1	0.0
AR	45,030	200	2,672	4.5	42.5	42.5	42.5	0.0
AS	46,120	230[3]	2,681	4.5	42.8	42.8	42.8	0.0
AT	48,080	160[3]	2,678	4.5	43.6	43.6	43.6	0.0
AU	50,450	160[3]	2,870	4.2	44.2	44.2	44.2	0.0

[1]Feet Above Corporate Limits [2]Width/Width Within Corporate Limits [3]Floodway Lies Entirely Outside Corporate Limits

TABLE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF KENT, WA
(KING CO.)

FLOODWAY DATA

GREEN RIVER

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
						(FEET NGVD)		
Green River (Cont'd)								
AV	51,400	150/80[2]	2,690	4.5	44.4	44.4	44.4	0.0
AW	54,470	170/70[2]	2,378	5.0	45.4	45.4	45.4	0.0
AX	56,030	125/80[2]	2,985	4.0	46.2	46.2	46.2	0.0

[1]Feet Above Corporate Limits [2]Width/Width Within Corporate Limits

TABLE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF KENT, WA
(KING CO.)

FLOODWAY DATA

GREEN RIVER

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD)			
Mill Creek								
A	0.109	63	474	1.4	18.1	18.1	19.1	1.0
B	0.138	60	322	2.0	18.1	18.1	19.1	1.0
C	0.737	49	331	2.0	19.5	19.5	20.2	0.7
D	0.788	50	323	2.0	20.3	20.3	21.0	0.7
E	1.083	56	405	1.6	22.3	22.3	22.8	0.5
F	1.410	57	328	2.0	22.7	22.7	23.2	0.5
G	1.476	41	300	2.2	22.8	22.8	23.3	0.5
H	1.660	40	276	2.4	23.9	23.9	24.3	0.4
I	1.767	50	349	1.9	24.9	24.9	25.3	0.4
J	1.803	38	325	1.6	25.2	25.2	25.5	0.3
K	1.992	37	277	1.9	25.3	25.3	25.8	0.5
L	2.203	43	346	0.8	25.6	25.6	26.0	0.4
M	2.294	42	311	0.9	25.5	25.5	26.0	0.5
N	2.357	32	254	1.1	25.7	25.7	26.2	0.5
O	2.545	41	210	1.3	25.8	25.8	26.3	0.5
P	2.612	38	270	1.0	25.9	25.9	26.4	0.5
Q	2.679	22	137	2.0	26.0	26.0	26.5	0.5
R	2.922	50	232	1.2	26.4	26.4	26.8	0.4
S	2.953	34	185	1.5	26.4	26.4	26.9	0.5
T	3.048	45	248	1.1	26.7	26.7	27.2	0.5
U	3.188	37	238	1.2	28.0	28.0	28.5	0.5
V	3.230	29	222	1.2	28.3	28.3	28.8	0.5
W	3.683	29	107	1.2	28.5	28.5	29.1	0.6
X	3.910	56	116	1.1	28.8	28.8	29.4	0.6
Y	3.943	47	78	1.7	30.0	30.0	31.0	1.0
Z	4.066	30	97	1.3	30.4	30.4	31.3	0.9

[1]Miles Above Mouth

TABLE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF KENT, WA
(KING CO.)

FLOODWAY DATA

MILL CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD)			
Mill Creek (Cont'd)								
AA	4.175	27	99	1.3	30.6	30.6	31.5	0.9
AB	4.202	16	82	1.6	31.4	31.4	32.3	0.9
AC	4.304	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
AD	4.393	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
AE	4.456	21	93	1.7	34.5	34.5	35.5	1.0
AF	4.485	13	72	2.2	34.9	34.9	35.9	1.0
AG	4.535	16	85	2.0	35.7	35.7	36.7	1.0
AH	4.562	17	92	1.8	35.8	35.8	36.8	1.0
AI	4.739	27	149	1.1	36.1	36.1	37.1	1.0
AJ	4.890	26	133	1.3	36.2	36.2	37.2	1.0
AK	4.996	17	96	1.8	36.4	36.4	37.4	1.0
AL	5.025	24	151	1.7	37.6	37.6	38.6	1.0
AM	5.232	20	94	2.7	38.4	38.4	39.3	0.9
AN	5.382	37	251	1.7	44.7	44.7	45.6	0.9
AO	5.436	47	60	7.2	47.1	47.1	47.2	0.1
AP	5.504	13	52	8.4	52.4	52.4	53.4	1.0

[1]Miles Above Mouth [2]Storage Floodway

TABLE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF KENT, WA
(KING CO.)

FLOODWAY DATA

MILL CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD)			
Springbrook Creek								
N	3.034	80	477	2.6	17.8	17.8	18.8	1.0
O	3.171	70	561	1.2	18.0	18.0	19.0	1.0
P	3.487	75	520	1.3	18.2	18.2	19.2	1.0
Q	3.804	88	453	1.5	18.6	18.6	19.6	1.0
R	3.954	59	328	2.0	19.2	19.2	20.2	1.0
S	4.082	100	733	0.9	23.0	23.0	24.0	1.0
T	4.289	50	316	2.1	23.2	23.2	24.1	0.9
U	4.336	92	739	0.9	23.3	23.3	23.5	0.2
V	4.508	30	303	1.7	23.4	23.4	23.6	0.2
W	4.633	33	238	2.1	23.5	23.5	23.8	0.3
X	4.823	29	218	2.3	23.7	23.7	24.0	0.3
Y	4.965	21	141	3.5	24.0	24.0	24.5	0.5
Z	5.134	28	211	2.4	24.6	24.6	25.2	0.6
AA	5.159	20	161	3.1	24.6	24.6	25.3	0.7
AB	5.364	30	202	2.5	25.4	25.4	26.1	0.7
AC	5.531	19	147	3.4	26.2	26.2	26.8	0.6
AD	5.567	24	174	0.7	26.5	26.5	27.1	0.6
AE	5.651	30	187	0.6	26.5	26.5	27.1	0.6
AF	5.802	28	122	0.9	26.5	26.5	27.2	0.7
AG	5.941	28	87	1.3	26.7	26.7	27.3	0.6
AH	6.074	19	59	2.0	27.3	27.3	27.7	0.4
AI	6.178	25	75	1.4	27.9	27.9	28.3	0.4
AJ	6.210	34	96	1.1	28.3	28.3	28.7	0.4
AK	6.359	28	60	1.8	28.6	28.6	29.0	0.4
AL	6.382	30	69	1.4	29.0	29.0	29.7	0.7
AM	6.464	35	81	1.2	29.2	29.2	29.8	0.6
AN	6.575	23	92	0.8	30.0	30.0	30.8	0.8

[1]Miles Above Mouth

TABLE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF KENT, WA
(KING CO.)

FLOODWAY DATA

SPRINGBROOK CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD)			
Springbrook Creek (Cont'd)								
AO	6.740	13	50	2.0	30.5	30.5	31.2	0.7
AP	6.852	25	99	1.0	30.8	30.8	31.4	0.6
AQ	6.889	30	130	1.5	31.6	31.6	31.6	0.0
AR	7.169	30	78	3.8	33.2	33.2	33.2	0.0

[1]Miles Above Mouth

TABLE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF KENT, WA
(KING CO.)

FLOODWAY DATA

SPRINGBROOK CREEK

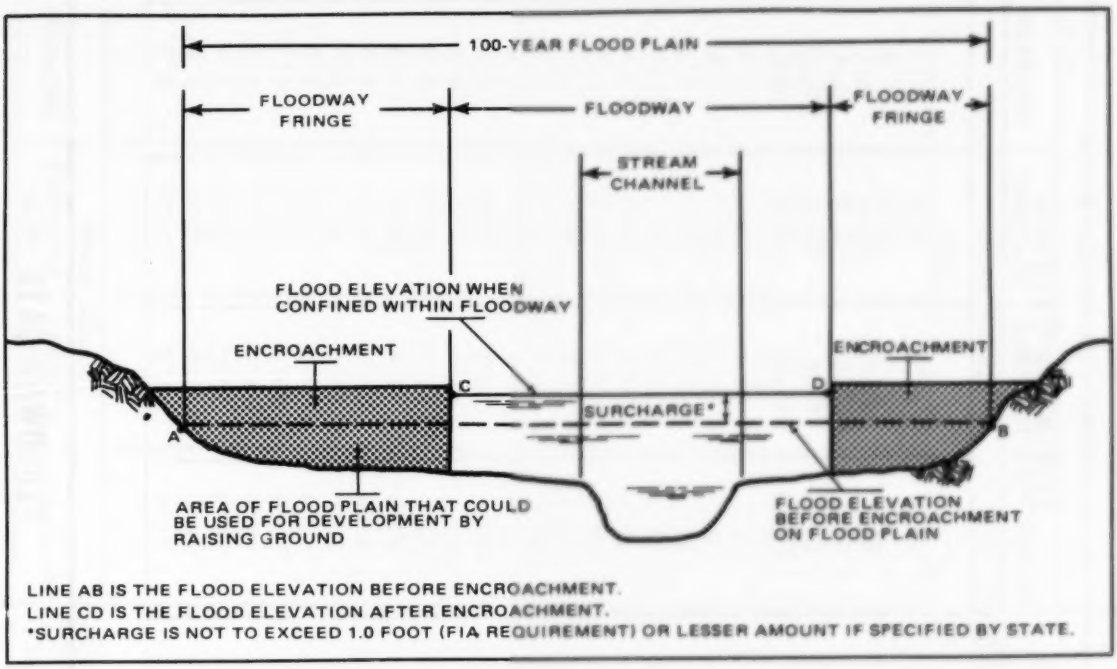
100-YEAR FLOOD PLAIN
FLOODWAY FRINGE
FLOODWAY
FLOODWAY FRINGE
STREAM CHANNEL
FLOOD ELEVATION WHEN CONFINED WITHIN FLOODWAY
ENCROACHMENT
ENCROACHMENT
C
D
SURCHARGE*
A
B
AREA OF FLOOD PLAIN THAT COULD BE USED FOR DEVELOPMENT BY RAISING GROUND
FLOOD ELEVATION BEFORE ENCROACHMENT ON FLOOD PLAIN
LINE AB IS THE FLOOD ELEVATION BEFORE ENCROACHMENT.
LINE CD IS THE FLOOD ELEVATION AFTER ENCROACHMENT.
*SURCHARGE IS NOT TO EXCEED 1.0 FOOT (FIA REQUIREMENT) OR LESSER AMOUNT IF SPECIFIED BY STATE.

Figure 2. Floodway Schematic

5.0 INSURANCE APPLICATION

In order to establish actuarial insurance rates, the Federal Insurance Administration has developed a process to transform the data from the engineering study into flood insurance criteria. This process includes the determination of reaches, Flood Hazard Factors, and flood insurance zone designations for each flooding source studied in detail affecting the City of Kent.

5.1 Reach Determinations

Reaches are defined as lengths of watercourses having relatively the same flood hazard, based on the average weighted difference in water-surface elevations between the 10- and 100-year floods. This difference does not have a variation greater than that indicate in the following table for more than 20 percent of the reach:

Average Difference Between 10- and 100-Year Floods	Variation
Less than 2 feet	0.5 foot
2 to 7 feet	1.0 foot
7.1 to 12 feet	2.0 feet
More than 12 feet	3.0 feet

The locations of the reaches determined for the flooding sources of Kent are shown on the Flood Profiles (Exhibit 1) and summarized in Table 3.

5.2 Flood Hazard Factors

The Flood Hazard Factor (FHF) is the Federal Insurance Administration device used to correlate flood information with insurance rate tables. Correlations between property damage from floods and their FHF are used to set actuarial insurance premium rate tables based on FHFs from 005 to 200.

The FHF for a reach is the average weighted difference between the 10- and 100-year flood water-surface elevations expressed to the nearest one-half foot, and shown as a three-digit code. For example, if the difference between water-surface elevations of the 10- and 100-year floods is 0.7 foot, the FHF is 005; if the difference is 1.4 feet, the FHF is 015; if the difference is 5.0 feet, the FHF is 050. When the difference between the 10- and 100-year water-surface elevations is greater than 10.0 feet, accuracy for the FHF is to the nearest foot.

5.3 Flood Insurance Zones

After the determination of reaches and their respective Flood Hazard Factors, the entire incorporated area of the City of Kent was divided into zones, each having a specific flood potential or hazard. Each zone was assigned one of the following flood insurance zone designations:

Zone A0:	Special Flood Hazard Areas inundated by types of 100-year shallow flooding where depths are between 1.0 and 3.0 feet; depths are shown, but no Flood Hazard Factors are determined.
Zone AH:	Special Flood Hazard Areas inundated by types of 100-year shallow flooding where depths are between 1.0 and 3.0 feet; base flood elevations are shown, but no Flood Hazard Factors are determined.
Zones A1, A2, and A3 and A4:	Special Flood Hazard Areas inundated by the 100-year flood, determined by detailed methods; base flood elevations shown, and zones subdivided according to Flood Hazard Factors.
Zone B:	Areas between the Special Flood Hazard Areas and the limits of the 500-year flood, including areas of the 500-

FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE[2] BETWEEN 1% (100-YEAR) FLOOD AND			FLOOD HAZARD FACTOR	ZONE	BASE FLOOD ELEVATION (FEET NGVD)[3]
		10% (10-YEAR)	2% (50-YEAR)	0.2% (500-YEAR)			
Green River							
Reach 1	0001,0002, 0004,0005	0.0[4]	0.0[4]	0.0[4]	005	A1	Varies - See Map
Mill Creek							
Reach 1	0001,0002, 0003	-2.1	N/A	N/A	020	A4	Varies - See Map
Reach 2	0003,0005	-0.3	N/A	N/A	005	A1	Varies - See Map
Springbrook Creek							
Reach 1	0001	-1.1	N/A	N/A	010	A2	Varies - See Map
Reach 2	0001,0003	-2.0	N/A	N/A	020	A4	Varies - See Map
Reach 3	0003	-0.8	N/A	N/A	010	A2	Varies - See Map
Reach 4	0003	-1.7	N/A	N/A	015	A3	Varies - See Map
Shallow Flooding	0001,0002, 0003	N/A	N/A	N/A	N/A	AH	Varies - See Map
Shallow Flooding	0003	N/A	N/A	N/A	N/A	AO	Varies - See Map

[1]Flood Insurance Rate Map Panel [2]Weighted Average [3]Rounded to Nearest Foot

[4]Data Based on Regulated Flow From Howard A. Hanson Dam

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF KENT, WA
(KING CO.)

FLOOD INSURANCE ZONE DATA

GREEN RIVER-MILL CREEK-SPRINGBROOK CREEK-SHALLOW FLOODING-SHALLOW FLOODING

year flood plain that are protected from the 100-year flood by dike, levee, or other water control structure; also areas subject to certain types of 100-year shallow flooding where depths are less than 1.0 foot; and areas subject to 100-year flooding from sources with drainage areas less than 1 square mile. Zone B is not subdivided.

Zone C: Areas of minimal flooding.

The flood elevation differences, Flood Hazard Factors, flood insurance zones, and base flood elevations for each flooding source studied in detail in the community are summarized in Table 3.

5.4 Flood Insurance Rate Map Description

The Flood Insurance Rate Map for Kent is, for insurance purposes, the principal result of the Flood Insurance Study. This map (published separately) contains the official delineation of flood insurance zones and base flood elevation lines. Base flood elevation lines show the locations of the expected whole-foot water-surface elevations of the base (100-year) flood. This map is developed in accordance with the latest flood insurance map preparation guidelines published by the Federal Insurance Administration.

6.0 OTHER STUDIES

The Flood Hazard Boundary Map for Kent (Reference 14) is in general agreement with, but superseded by, this Flood Insurance Study.

A Flood Insurance Study has been completed for King County, Washington (Reference 6). The Kent Flood Insurance Study is not in agreement with the King County Flood Insurance Study, due to errors in the King County study for Green River. The King County study is being revised to correct these errors. The revised Flood Insurance Study for King County will be in agreement with this Flood Insurance Study.

The U.S. Soil Conservation Service has conducted extensive unpublished studies in Green River valley, directed primarily toward determining criteria pertinent to the design of flood-control drainage channels and associated structures. These studies have been mainly concerned with the effects of future land use and development on runoff patterns, rather than existing flood-hazard conditions.

This study is authoritative for the purposes of the National Flood Insurance Program; data presented herein either supersede or are compatible with all previous determinations.

7.0 LOCATION OF DATA

Survey, hydrologic, hydraulic, and other pertinent data used in this study can be obtained by contacting the Insurance and Mitigation Division, Federal Emergency Management Agency, Federal Regional Center, 130 228th Street, SW., Bothell, Washington 98011.

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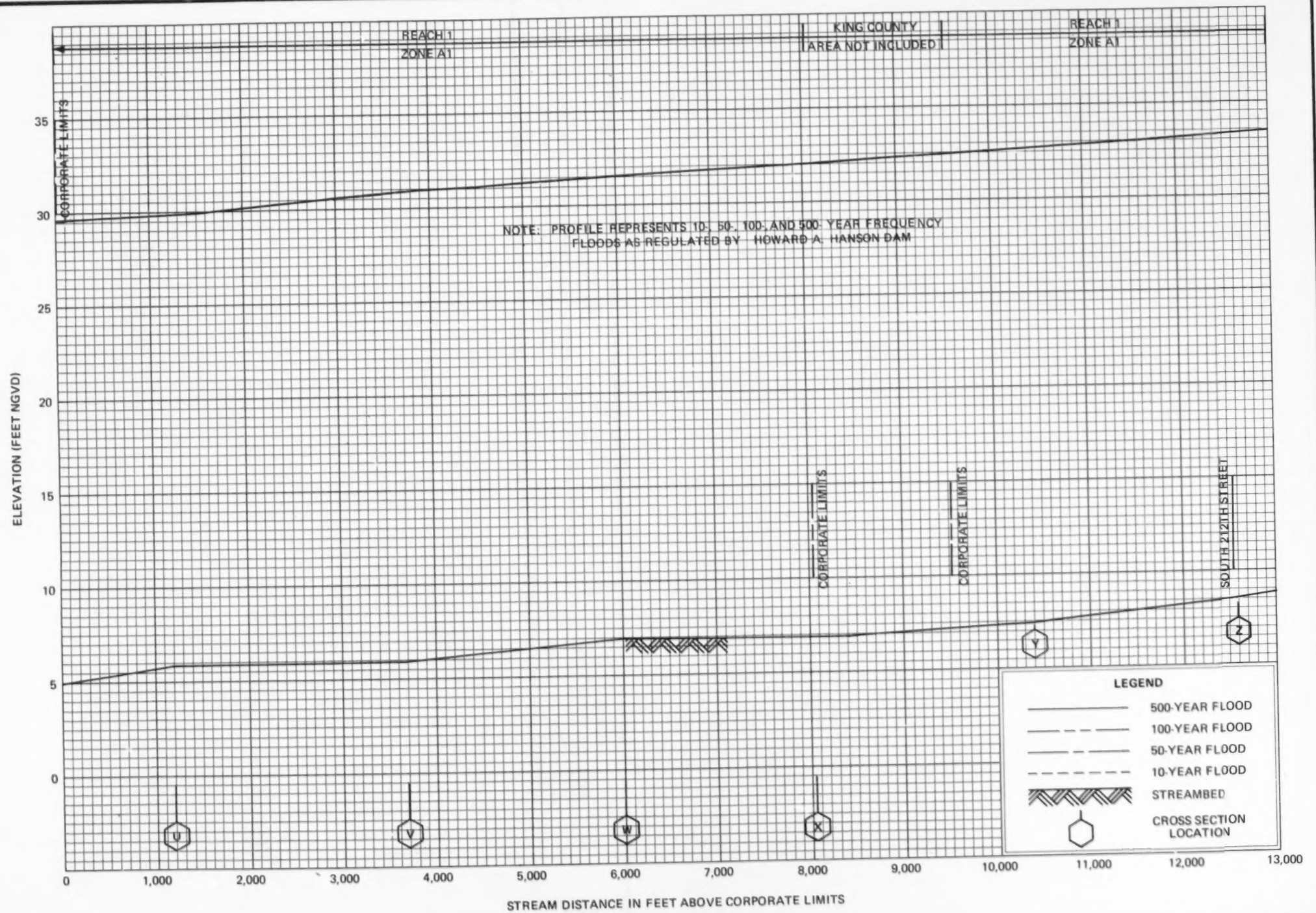

FLOOD PROFILES

GREEN RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF KENT, WA
(KING CO.)

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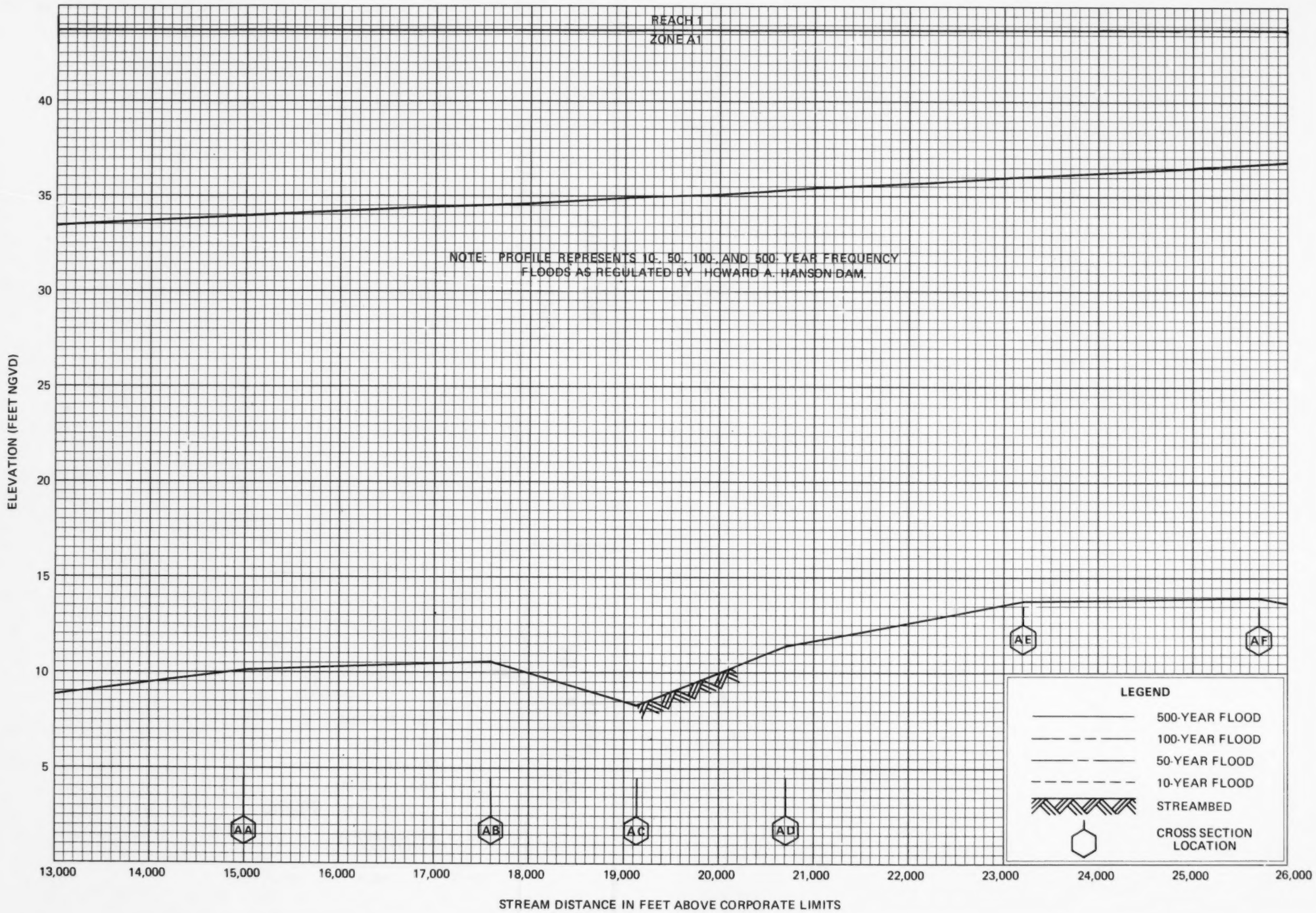

FLOOD PROFILES

GREEN RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF KENT, WA
(KING CO.)

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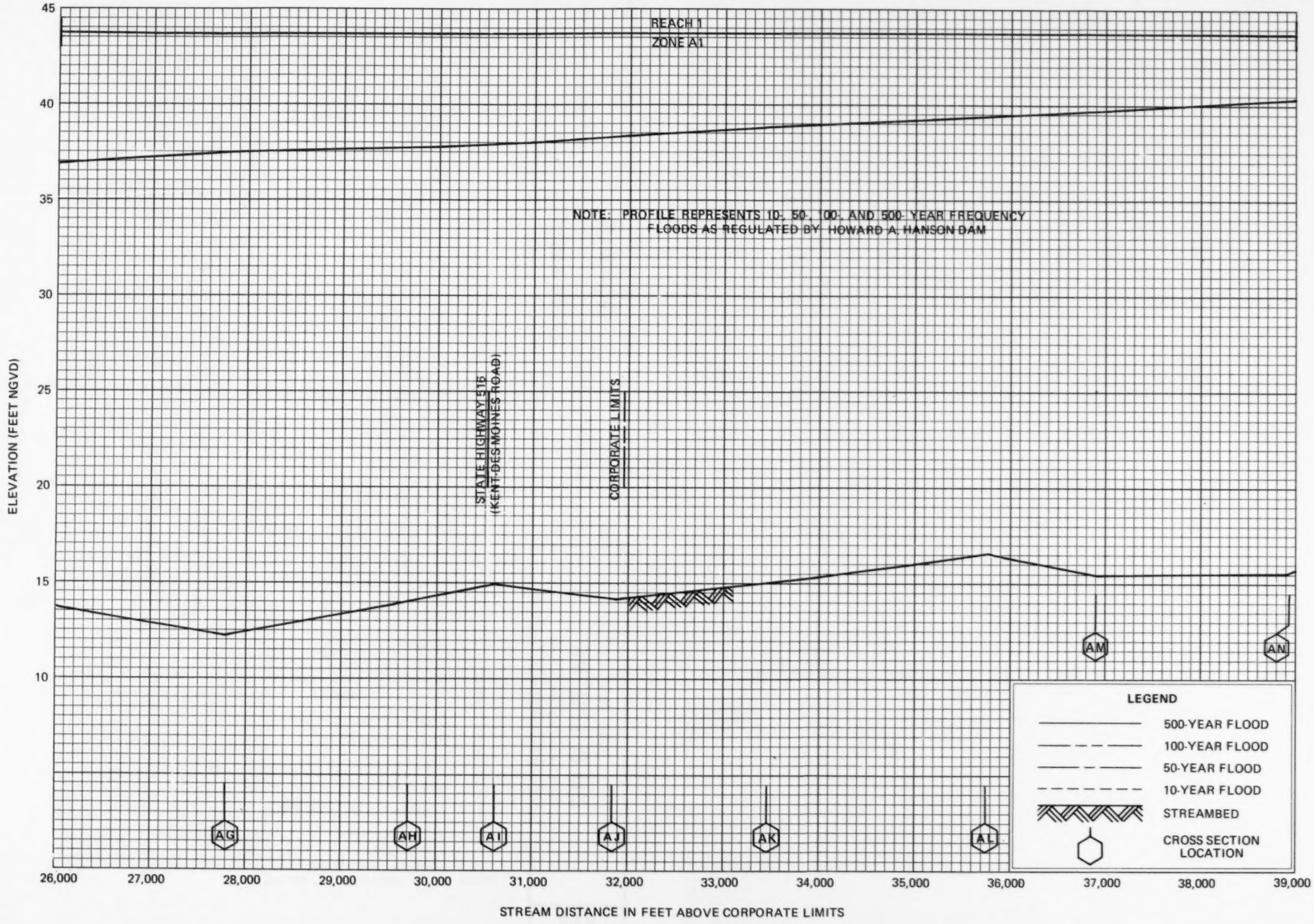

FLOOD PROFILES

GREEN RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF KENT, WA
(KING CO.)

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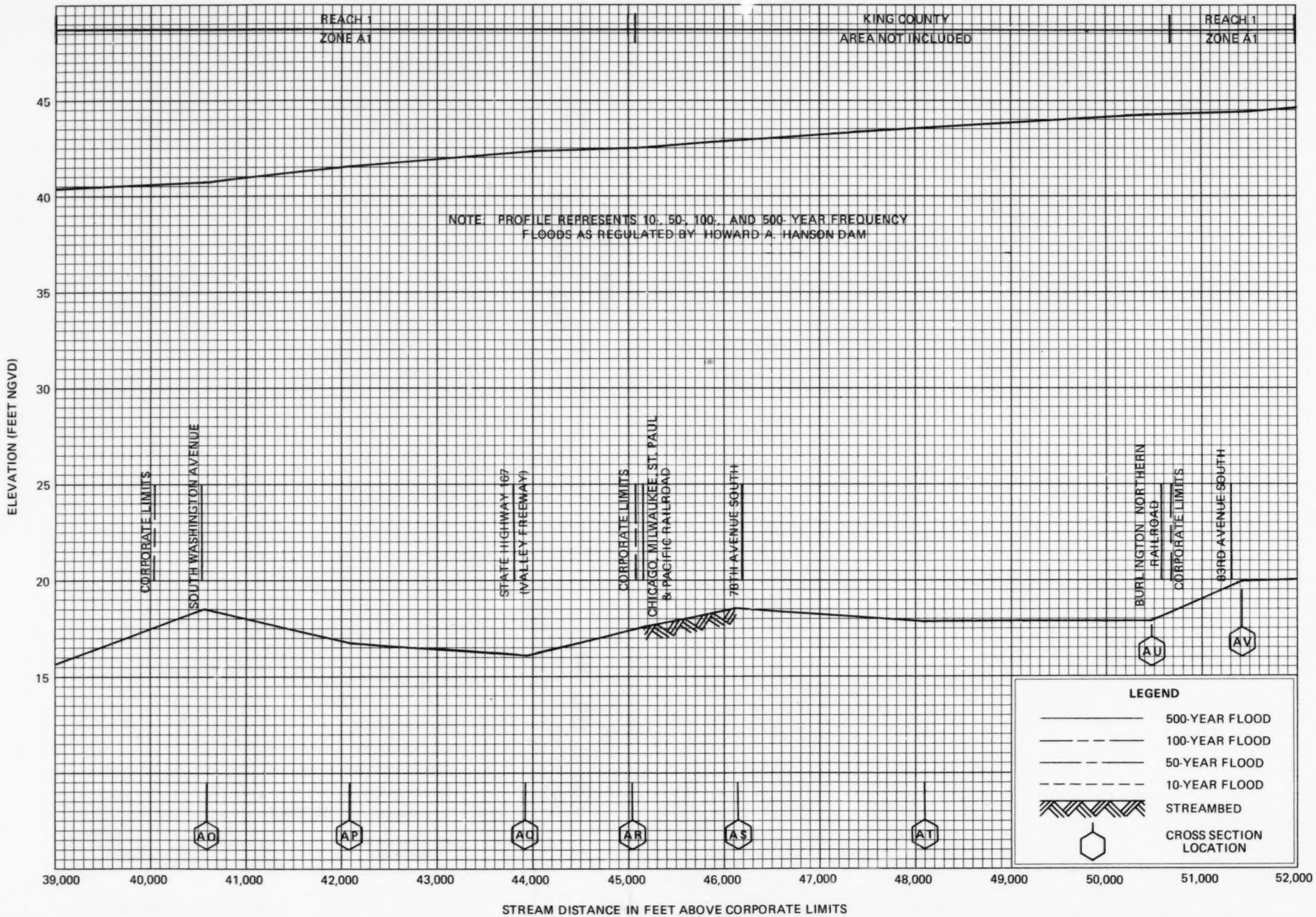


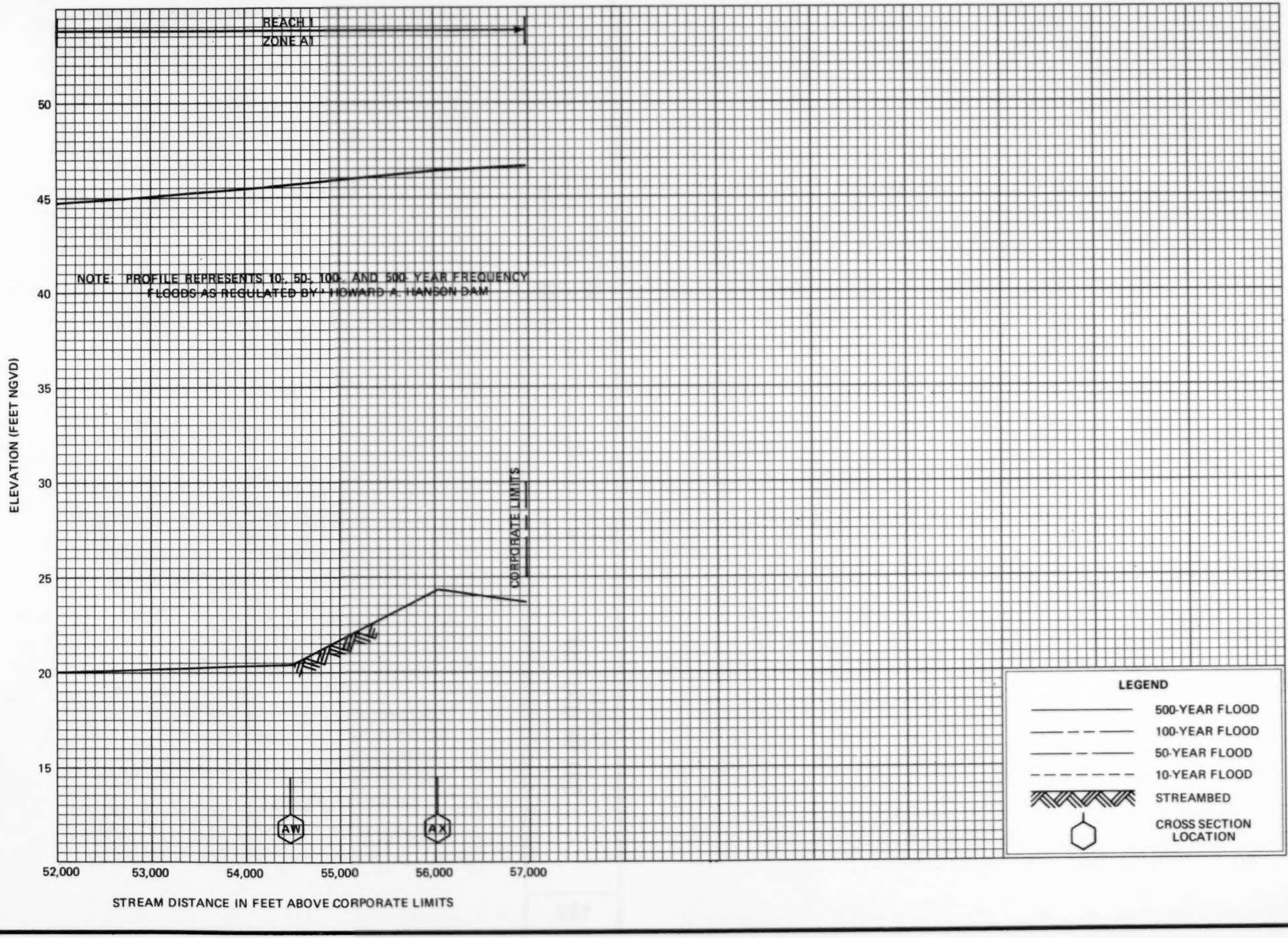
FLOOD PROFILES

GREEN RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF KENT, WA
(KING CO.)

04P



FLOOD PROFILES

GREEN RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF KENT, WA
(KING CO.)

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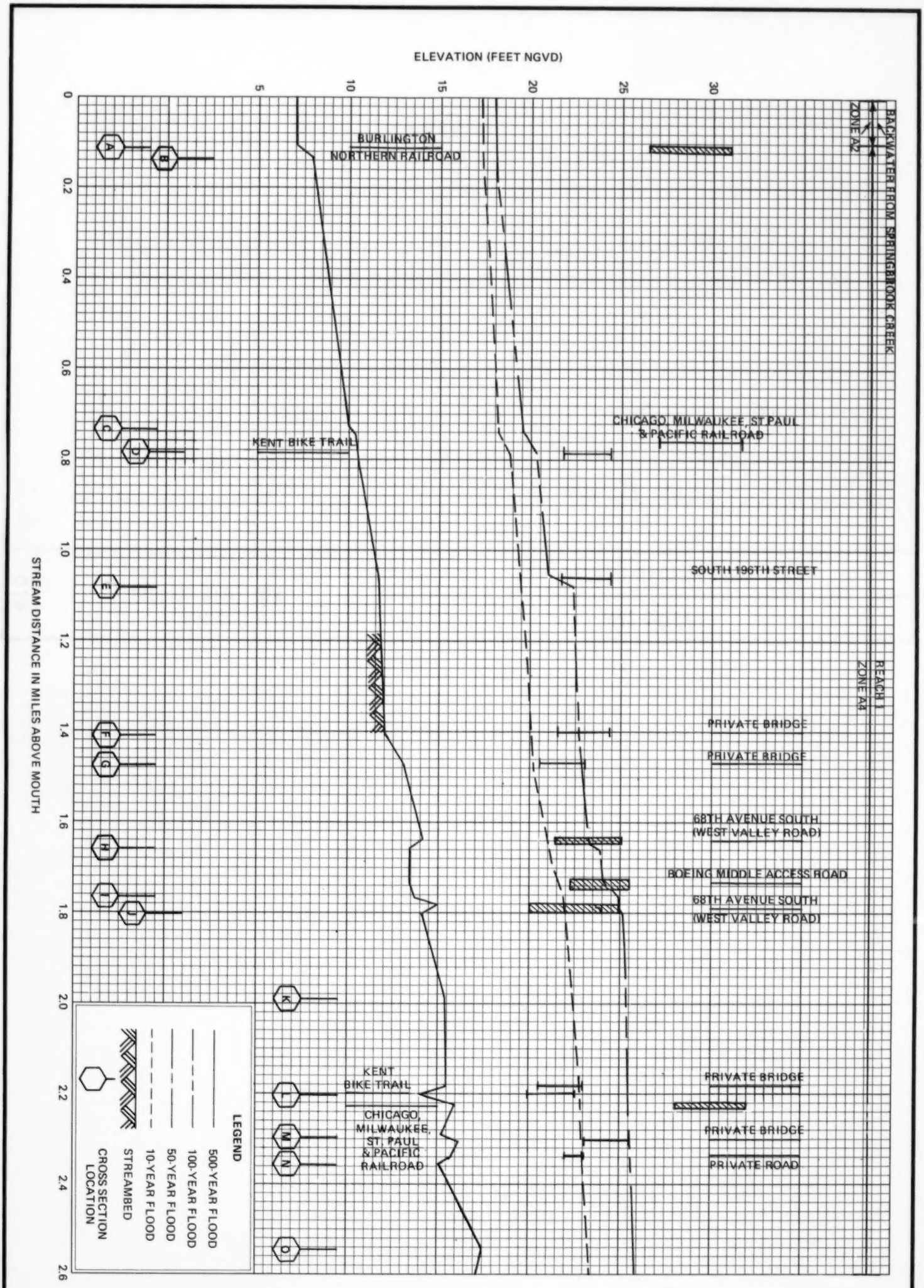

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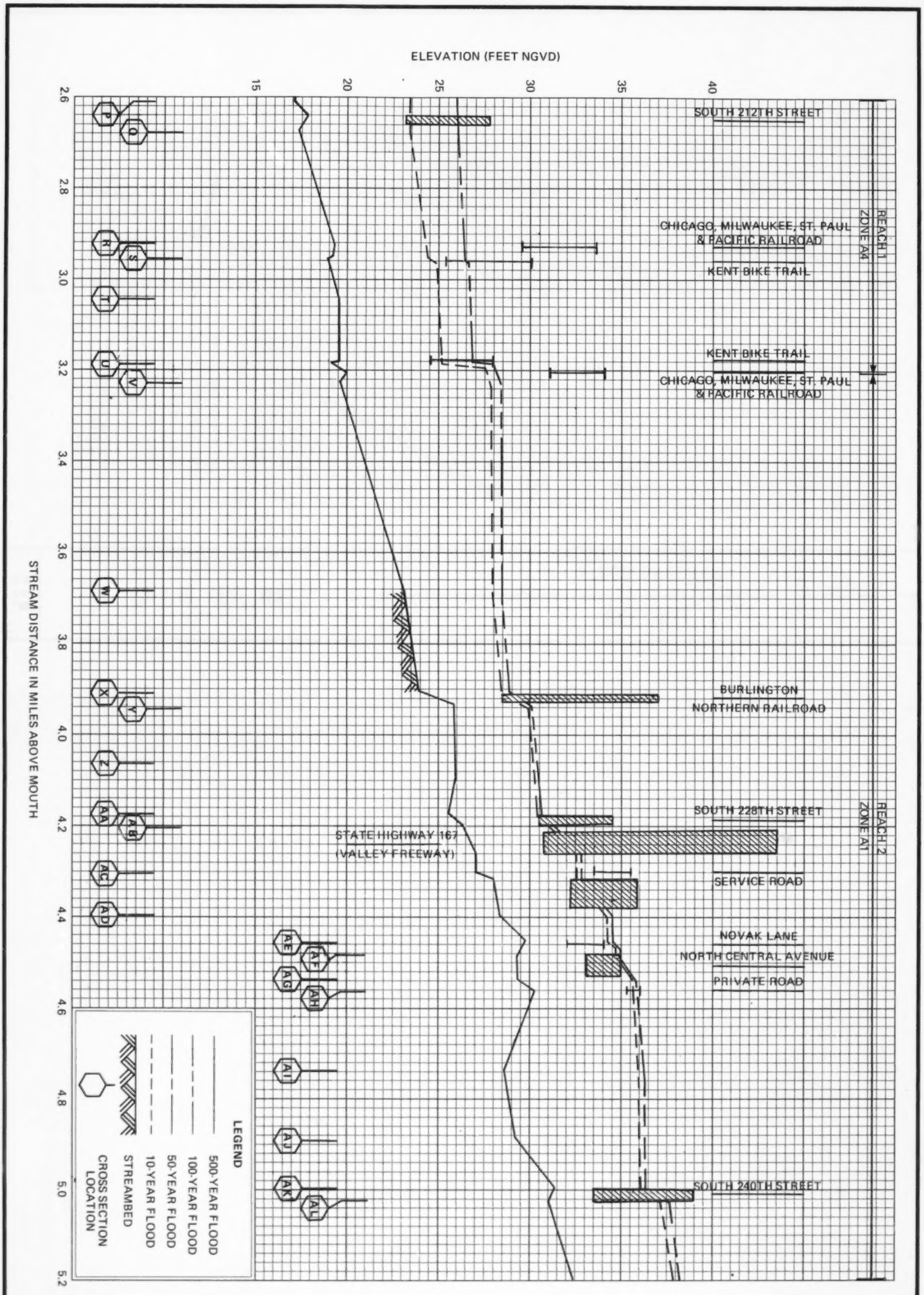
FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF KENT, WA
(KING CO.)

FLOOD PROFILES

MILL CREEK



FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF KENT, WA
(KING CO.)

FLOOD PROFILES

MILL CREEK

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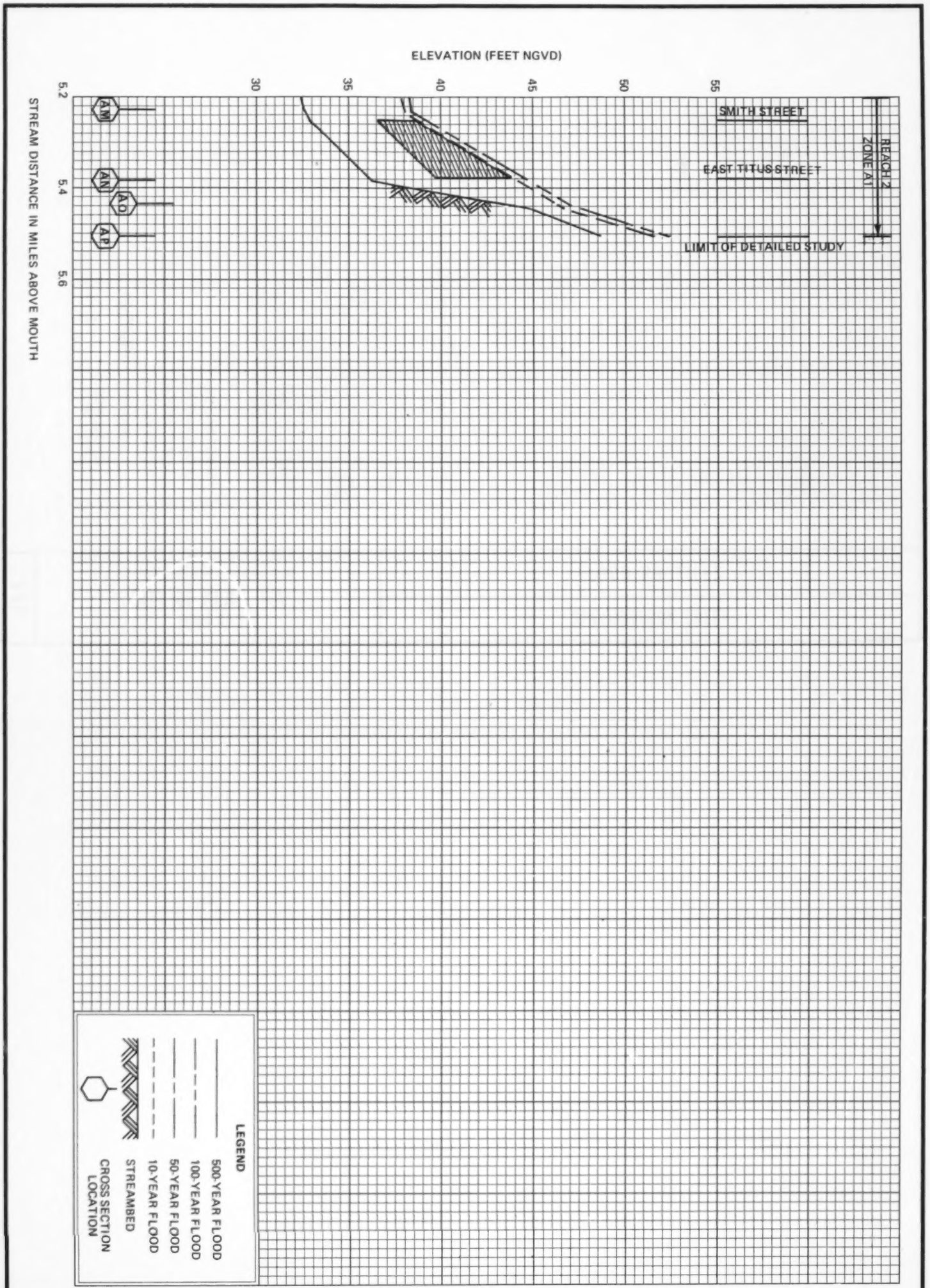

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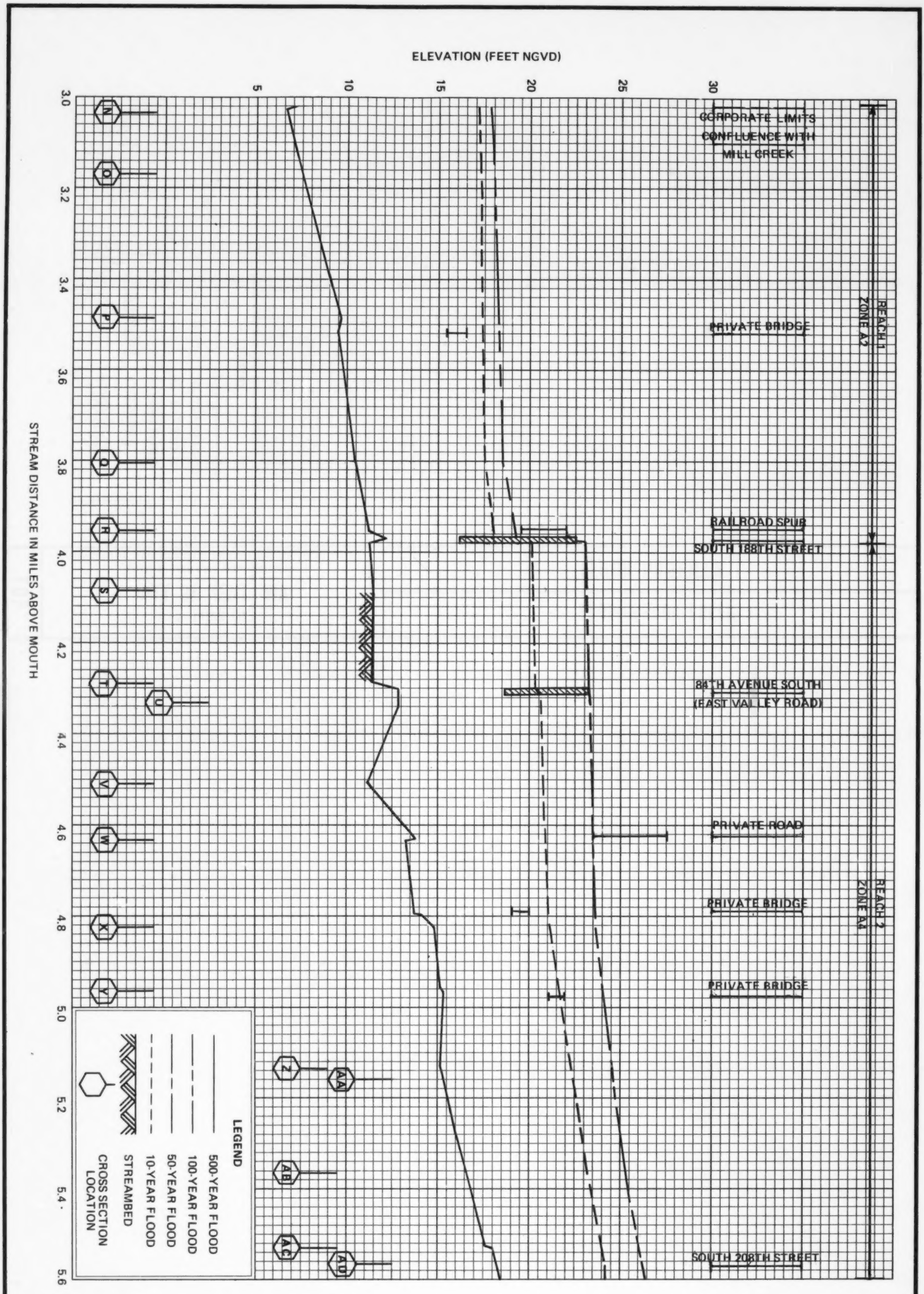

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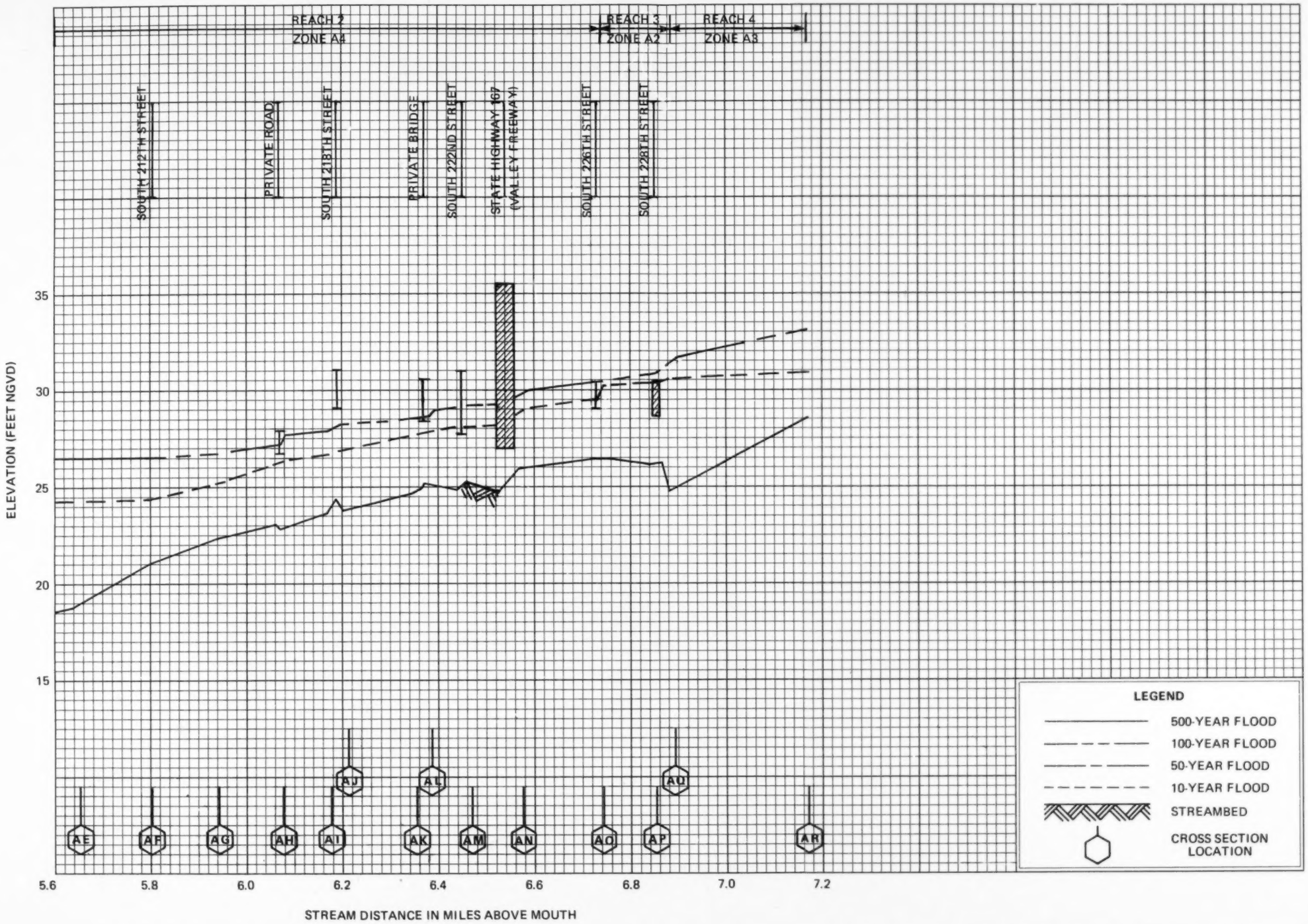
FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF KENT, WA
(KING CO.)

FLOOD PROFILES

SPRINGBROOK CREEK



FLOOD PROFILES

SPRINGBROOK CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF, KENT, WA
(KING CO.)

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